The
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RESEARCH AREAS

Climate Change : Data Analysis : Electrical Resistivity Tomography
Time Domain Reflectometry : BioSciences : Ground Movement
Soil Testing Techniques : Telemetry : Numerical Modelling
Ground Remediation Techniques : Risk Analysis
Mapping : Software Analysis Tools
Electrokinesis Osmosis
Intelligent Systems

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Climate Change • Data Analysis • Electrical Resistivity Tomography
Time Domain Reflectometry • BioSciences • Ground Movement
Soil Testing Techniques • Telemetry • Numerical Modelling
Ground Remediation Techniques • Risk Analysis
Mapping • Software Analysis Tools
Artificial Intelligence

Edition 144

May 2017

The Clay Research Group

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Edition 144. May, 2017.

Urban Tree Conference

The International Urban Tree Conference, "Trees, People and the Built Environment 3", was held at Birmingham University, Edgbaston, on the 5th and 6th April and contained a range of research papers and presentations all downloadable from the following web site…

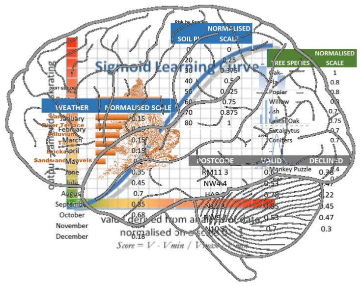
http://www.charteredforesters.org/event/icf-trees-people-built-environment-3/

Extracts from the TDAG draft paper outlining topics for discussion appear on pages 2 and 3, together with some initial thoughts.

THE CLAY RESEARCH GROUP
www.theclayresearchgroup.org
clayresearchgroup@gmail.com

Neuroscience, Subsidence and A*i*. Looking for the Link.

Remarkable similarities between two approaches – one looking at the brain, mapping semantics, and the other developing A*i* systems in the field of domestic subsidence. More inside.



The Value of Shared Experience

Prof. Eduardo Alonso, Chairman and Honorary Editor of Géotechnique, expresses the following view in a recent edition of the journal *"… our learning process is vastly improved if we learn from the experience of others. Good case histories are necessary contributions, complementing the theoretical and experimental research being published in Géotechnique."* An important point made by the editor of the highly-regarded journal, and one we share. If you have a case history that would be of interest to our readers, please consider sharing it.

Edition 144

This edition marks the newsletters 12th anniversary. To celebrate we are publishing a series of risk maps over the next few months, concentrating on London and covering geology, trees, claims, clay index, '% passing', properties, housing types etc.

TDAG – Looking to the Future

TDAG are exploring "issues relating to trees, insurance, subsidence and how to overcome conflicts in creating more liveable, sustainable urban environments". They have produced a list of topics for discussion, which includes the following:

1. Should new homes built on clay soil have foundations that can cater for the presence of either existing trees, or any that might be planted at some future date?

2. Would insurers be willing to offer a reduced premium for homeowners with 'tree proof' foundations?

3. Builders already comply with NHBC codes relating to foundation depths covering existing trees. Would developers and purchasers be willing to meet the addition cost to protect homes for the future?

4. What would the extra cost be? We are making enquiries but initial thoughts are this might amount to an increase of around 8%.

5. More trees are needed but where should they be planted? Back gardens, private land etc., all offer opportunities and with less risk than street trees.

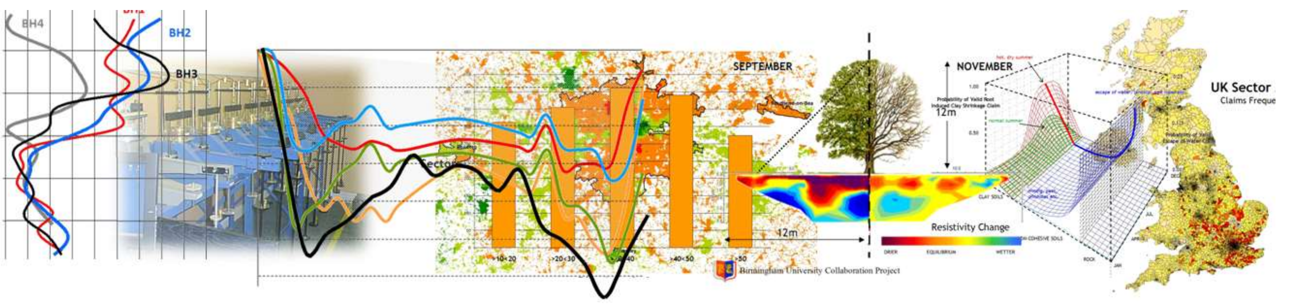
The author of the draft says "We are told that we need to build c. 250,000 p.a. to meet the present shortage and that we will need an additional c. 3 million dwellings to meet the anticipated population increase of 10 million people over the next 25 years. It is critical that we do not build in future problems."

This is a very brief extract from the comprehensive list produced in the TDAG discussion sheet and reinforces comments received a few weeks ago from Andrea Plucknett, Welwyn Hatfield Borough Council, expressing the view that insurers and local authorities should work together to resolve the problem. Andrea suggests that when insurers have data or information relating to a particular risk it would be a good idea to share it, to avoid disputes and litigation wherever possible.

The fact is, homeowners are paying either by way of increases in domestic rates or insurance premiums, and given environmental concerns, a resolution is essential if we are to cater for more homes and the planned increase in canopy cover.

Peter Osborne of TreeSubs mischievously made the point a few years ago at an Aston Conference that if insurers provide subsidence cover, why do they shy away from meeting their liabilities when damage occurs?

Insurers might reply that damage resulting from tree root nuisance is often recoverable at law. Owners of trees have responsibilities. We can't own something that is causing damage and escape liability, as worthy as the item causing damage might be



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CAVAT is undoubtedly a useful tool to estimate tree values but putting a value against something doesn't absolve owners from their liabilities.

Working together is essential, with each party recognising the issues faced by the other. In practical terms we would make the following observations.

Any changes in foundation depths won't reduce the current exposure significantly and any reduction in the insurance premium will be small. The average spend by insurers on domestic subsidence is around 4% which equates to something like £20 or so on average across the UK. More in London of course.

The increased cost of providing a piled foundation, reinforced raft, concrete edge beam and the necessary anti-heave precautions will probably exceed £25k, and a premium reduction of £20 p.a. may not be attractive to the homeowner in purely financial terms, although they may get comfort from the reduced risk of subsidence.

On the other hand, the increase in foundation depths proposed by the NHBC over 30 years ago probably met with some scepticism at the time, but are now welcomed by developers, insurers and homeowners. Deeper foundations for houses on clay soil would resolve the problem of how buildings and trees can live together going forward. A major benefit.

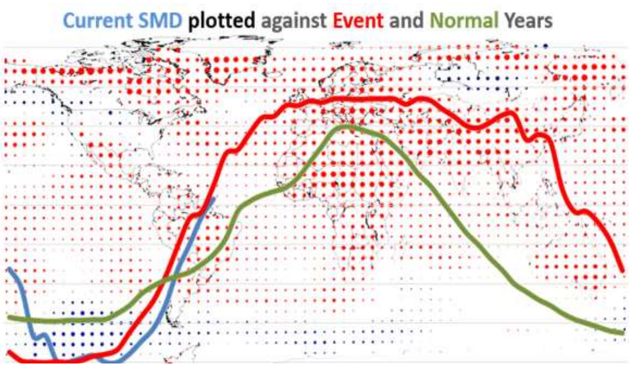
The work undertaken by TDAG has great value and could have wide-ranging implications for insurers and local authorities – as well as engineers and adjusters.

This is an important topic for domestic subsidence practitioners and we welcome thoughts, comments and constructive suggestions on the proposals.

That said, the current situation of a housing stock vulnerable to tree root nuisance remains unchanged. The discussions should include how we work together going forward to reduce the cost of such claims and the distress caused to homeowners.

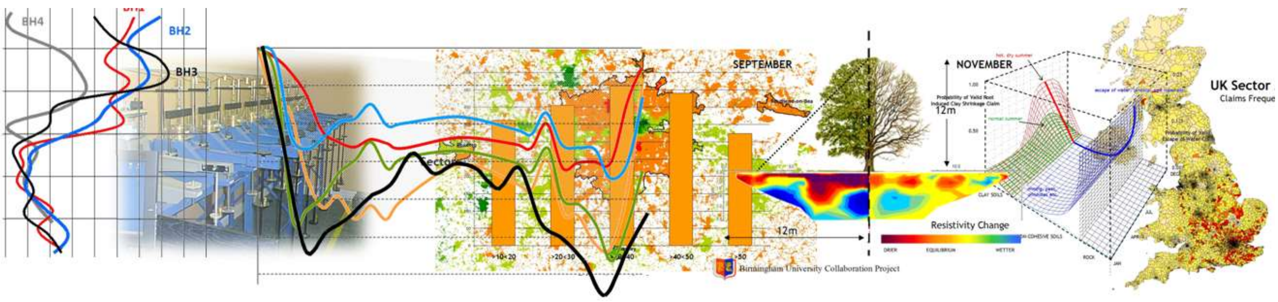
SMD Update

Interesting year ahead – maybe? Below, the Soil Moisture Deficit graph for tile 161 in the south east of the UK showing drying soils following a typical 'dry year' profile.



Soil Moisture Deficit for tile 161, supplied by the Met Office for medium AWAC soils and grass cover. The blue line represents the data for 2017 and the current situation shows soil drying close to that of an event year profile.

Obviously far too early to draw and conclusions but noteworthy in the world of domestic subsidence.



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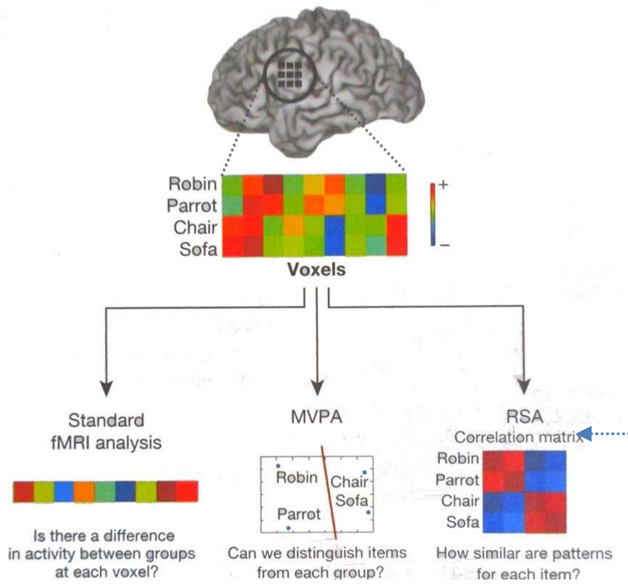
Domestic Subsidence, Intelligent Systems and fMRI Scans

Shared Methodology

Neuroscientists use a technique known as **f**unctional **M**agnetic **R**esonance **I**maging (fMRI) to understand how the brain works. A recent article in the journal Nature on mapping the cortex (brain surface) proved to be particularly interesting.

Entitled "Progress and Challenges in Probing the Human Brain", by Russell *et al*, Nature, 15th October 2015, the research team found that every word has a specific location on the cortex.



Another part of the brain then undertakes the interpretation and classification. When shown a series of words – for example, seagull, robin, sparrow, blackbird – another part of the brain recognises the words as falling into the category "birds".

What does this have to do with subsidence?

For 'cortex', substitute 'subsidence database'. For 'fMRI imaging', substitute 'thematic mapping by value'.

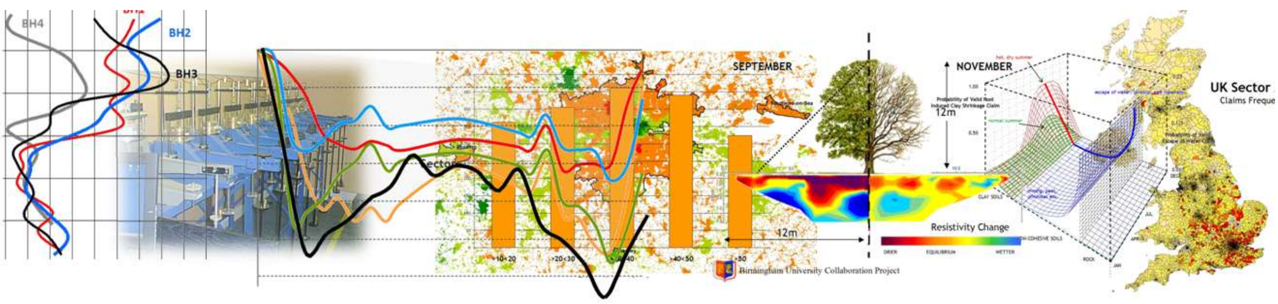
Clay Shrinkage

0.62	0.36	0.27	0.165	0.06
0.77	0.6325	0.495	0.3575	0.22
0.58	0.46	0.36	0.265	0.17
0.65	0.51	0.385	0.2475	0.11
0.59	0.53	0.385	0.2475	0.11
0.71	0.57	0.42	0.27	0.12
0.83	0.6675	0.515	0.3625	0.03

Above, mapping values to identify claim validity and peril appeared in edition 137 of the newsletter. The approach resembles that shown in the image, left, under "RSA Correlation Matrix". The "Standard fMRI analysis" image is the one used in our database analysis – see following page.

Regarding the classifier, substitute a series of risk tables, graphs and/or algorithms. When assembled, this faux brain carries out the analysis required to deliver a probability of (a) whether a claim is likely to be valid or declined and (b) the most likely operating peril.

The output is a value that can be compared with other scores to build distributions – and all by sector and taking into account prevailing weather conditions at date of notification etc.



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Resolving the Claims Database

The first step is to build a structured claim (rather than policy) database. Many insurers and adjusting practices already have them. The next step is ensuring that the database contains all of the fields that have been identified as risk indicators.

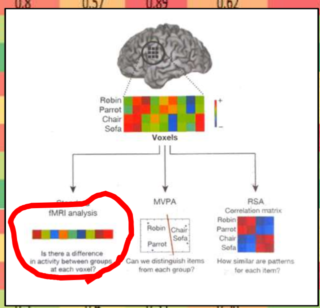
In previous editions, we have looked at individual risk tables for postcode location trees, geology, weather, age of property etc. Below, our 'thematic imaging', or pseudo fMRI map, colour coding the risk attribute listed in the various underlying tables.

The individual values of these added together and the output re-calculated (again on a 0 – 1 scale), in the right-hand column.

The initial outcomes are then compared with the number of claims we might anticipate as being valid, by peril, in a particular season historically, taking into account patterns at the time of damage.

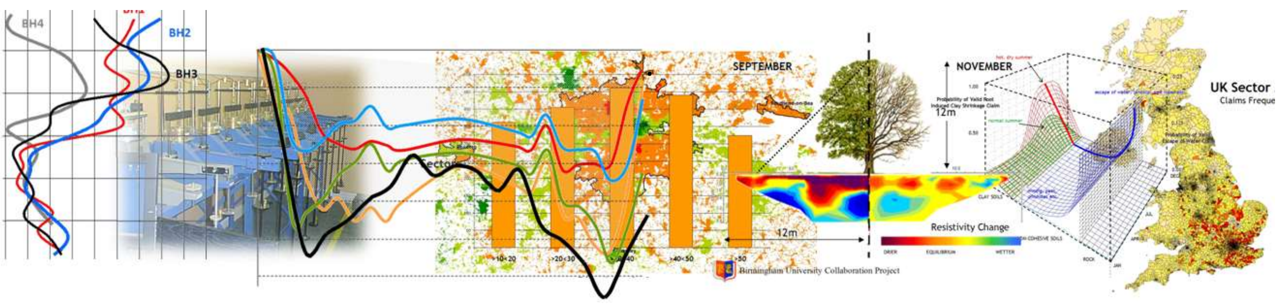
In a particularly dry year, the number of valid claims, expressed as a percentage of those received, might be expected to increase to say 80%.

Policy No.	Inception	Date Damage	Date of Notification	Property Age	Property Type	Geology	Damage Location	Vegetation	Sector Risk	Risk		Normalised Value
PGD37266	0.1	0.3	0.32	0.82	0.22	0.43	0.08	0.25	0.6	3.12	0.155922039	0.460176
PGD38821	0.2	0.2	0.88	0.46	0.62	0.55	0.4	0.22	0.38	3.91	0.195402299	0.576695
PGD88241	0.7	0.82	0.82	0.8	0.57	0.89	0.62	0.87	0.69	6.78	0.338830585	0.999999
PGD73053	0.33	0.37	0.35	[illegible]	[illegible]	[illegible]	[illegible]	0.1	0.2	2.96	0.147926037	0.436578
PGD19025	0.73	0.63	0.52	[illegible]	[illegible]	[illegible]	[illegible]	0	0.18	3.24	0.16191904	0.477876
PGD37266	0.1	0.3	0.32	[illegible]	[illegible]	[illegible]	[illegible]	0.25	0.6	3.12	0.155922039	0.460176
PGD38821	0.2	0.2	0.88	[illegible]	[illegible]	[illegible]	[illegible]	0.22	0.38	3.91	0.195402299	0.576695
PGD88241	0.7	0.82	0.82	[illegible]	[illegible]	[illegible]	[illegible]	0.87	0.69	6.78	0.338830585	0.999999
PGD73053	0.33	0.37	0.35	[illegible]	[illegible]	[illegible]	[illegible]	0.1	0.2	2.96	0.147926037	0.436578
PGD19025	0.73	0.63	0.52	[illegible]	[illegible]	[illegible]	[illegible]	0	0.18	3.24	0.16191904	0.477876
PGD37266	0.1	0.3	0.32	[illegible]	[illegible]	[illegible]	[illegible]	0.25	0.6	3.12	0.155922039	0.460176
PGD38821	0.2	0.2	0.88	[illegible]	[illegible]	[illegible]	[illegible]	0.22	0.38	3.91	0.195402299	0.576695
PGD88241	0.7	0.82	0.82	[illegible]	[illegible]	[illegible]	[illegible]	0.87	0.69	6.78	0.338830585	0.999999
PGD73053	0.33	0.37	0.35	[illegible]	[illegible]	[illegible]	[illegible]	0.1	0.2	2.96	0.147926037	0.436578
PGD19025	0.73	0.63	0.52	0.1	0.66	0.2	0.22	0	0.18	3.24	0.16191904	0.477876



Then build a parallel copy of the database that translates text ("Geology is outcropping London clay") to a normalised score on a scale 0 - 1 by referring to the various associated risk tables. In the example of the geology, the score for London clay would be around 0.7, depending on the location, obtained from postcode.

The distribution should reflect this. If the scores reveal that the claims in any particular classification (i.e. valid/declined by peril) are significantly higher or lower than would be expected based on experience (see chart on following page as an example of 'experience' taking account of weather and season), the normalisation process automatically adjusts the output values.



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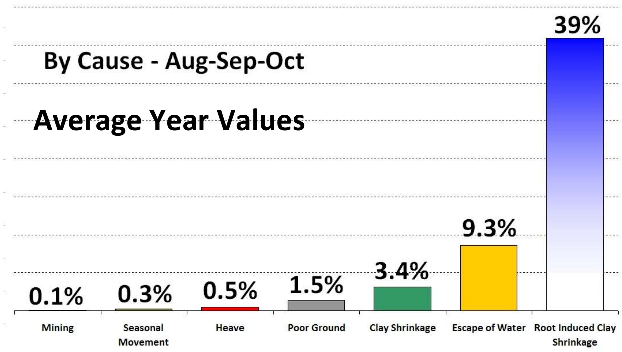


The historic distribution by peril, sector and by season. Are the decisions made by the system matching historic experience? If not, then the distribution analysis adjusts the output scores accordingly. See Newsletter 92, January 2013.

In cases of clay shrinkage, the claim handler would then check the proximity of any vegetation in the vicinity of damage using LiDAR or Google to establish a confidence factor.

The confidence factor for non-cohesive soils is far lower but there will be cases where the proximity of damage to a drain or pattern of distress will refine the estimate.

Scales of individual risk elements are adjusted by other values in the table. For example, if the soil has a zero, or a low score (i.e. is not shrinkable), it acts as a multiplier to the vegetation factor. Vegetation has an adjusted 0 – 0.3 scale (rather than 0 – 1) to take account of localised geological variations.

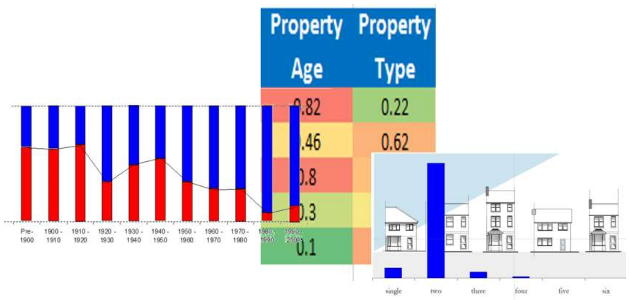
Similarly, older houses are more vulnerable, but not all suffer damage and the associated risk has a scale adjusted to its significance. Instead of appearing on a 0 – 1 scale, it's smaller contribution recognised by adjusting the risk scale to 0 – 0.3.

Returning now to the point about the Policy Inception heading. We have no evidence of a link, but the database will carry out the analysis and by marking every claim 'valid or declined' and the peril, it is an easy enough to find if there is one, and if there is, its value on the scale of 0 – 1.

This can be applied to all of the headings for which we do not currently have a score.

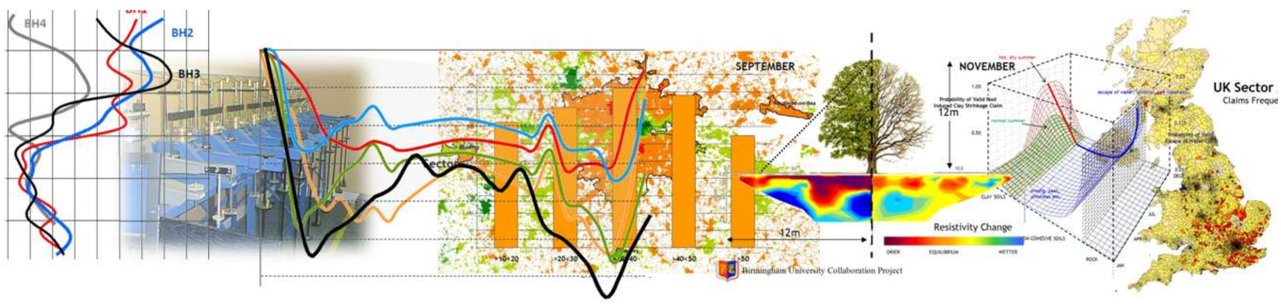
Care is needed when attributing values to individual elements. For example, the extract below shows a risk by property style. The highest risk is the two-storey house, naturally.

This is because there are far more of them in the housing stock. The ubiquitous semi-detached has a high score for the same reason.



But does the score reflect the location, density and geology of such housing? In an earlier edition we mapped the distribution of housing styles across the UK. Is it simply that there are more semi-detached houses on outcropping clay that puts them at the top of the league table, or their dominance in terms of numbers?

Individual element have to be considered against their location, geology, significance (see comments bottom left) and frequency templates.



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The underlying analysis has to resolve this sort of question both 'by geology' and 'by location'. How many semi-detached houses have been damaged, compared with the number by style on a particular soil and demographic?

Few bungalows may be damaged simply because there are fewer of them, but in terms of risk they may be at the top of the table. Do they suffer more from leaking drains, or clay shrinkage?

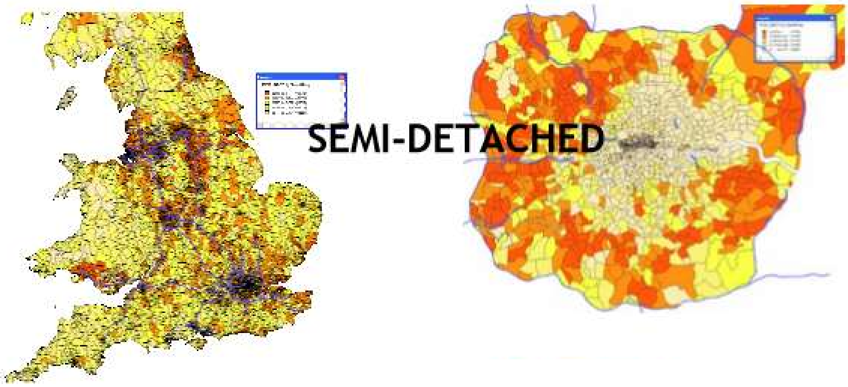
As can be seen, there is work to do before launching the application.

The best way of accounting for this possible, but less tangible, variation is analysis of the historic data.

The end game is the attribution of a normalised score against each heading. Building a template of what a valid claim looks like, by peril.

At the bottom of this column, an extract from the database showing the derived score. The highest score – the most likely to be valid, is 0.99. Twice that of the lowest (0.44).

These are relative, rather than absolute, values.



Distribution of risk by house style has to take account of the geology and frequency. Are more houses of one particular style more vulnerable, greater in number or only vulnerable to particular perils?
Issue 79, December 2011.

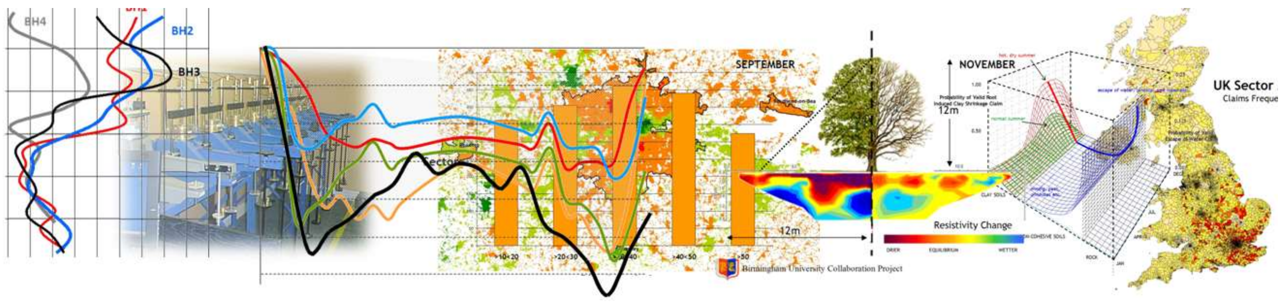
Every claim is represented by data in a horizontal field, recording the individual scores by element. Weather, geology, vegetation, age of property etc., and correlation techniques are used to assess their significance.

The subsequent discussion with the homeowner – or providing them with access to a web based application to both review this information and add more detail as prompted, should resolve around 40 – 50% of all claims in event years.

ation	Sector Risk	Risk		Normalised Value
5	0.6	3.12	0.155922039	0.460176
2	0.38	3.91	0.195402299	0.576695
7	0.69	6.78	0.338830585	0.999999
	0.2	2.96	0.147926037	0.436578

(Claims by style/total houses by style) by peril by geology = risk by style

Demographics. Is it the case that a 5mm crack in one part of the country is regarded as something to be filled when the room is next decorated, whilst similar damage in another part of the country is a major issue with substantial cost implications in terms of re-sale values?



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Water Uptake Resulting in Ground Movement

Aldenham Willow

Estimating the water uptake of the willow has been mentioned in earlier editions of the newsletter, and the answer is as elusive as ever.

Web searches provide a wide range of estimates, from around 100 gallons a day to several thousand.

The objective of this assessment is to estimate how much water is taken by the tree to produce ground movement. This isn't an estimate of total water uptake by the tree.

Precise levels provide an accurate record of ground movement at the site of the Aldenham willow, and after taking advice from Tim Freeman, MD of GeoServ and former head of foundation research at the Building Research Establishment (BRE), estimates have been derived using this ground movement data.

The method is based on the recommendations contained in BRE Digest 412, relating to estimating ground heave based on moisture content, but 'worked backwards'.

Whereas the Digest provides guidance on how to estimate ground heave from moisture contents, Tim has helped to explain how we can estimate water loss using ground movement values derived from precise levels.

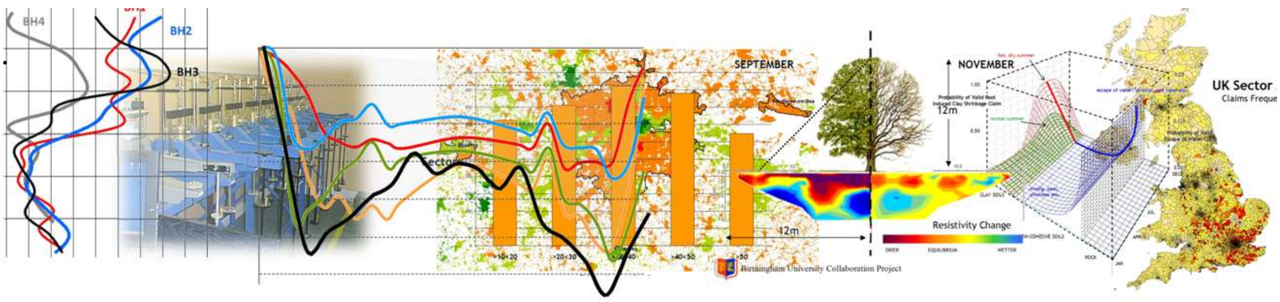
According to the BRE Digest 412, the estimated total swell is divided by a factor of 4 – the Water Shrinkage Factor (WSF) based on empirical evidence.

This takes account of water in the soil mass that doesn't contribute towards volumetric change and is an empirical value based on the earlier work of Ward.

Tim explains *"if you wanted to calculate moisture extraction based on the levelling data (on a month by month basis), I would take an average of the change recorded in a particular month and then multiply by 4 (the water shrinkage factor) to calculate the change in volume. For example an average settlement of 5 mm over the root zone would equate to 0.005 x 4 x 1963 = 49 m3. Or for simplicity every 1 mm of vertical movement represents 10m^3 of water extraction"*.

With this guidance, and taking account of what Giles Biddle says (i.e. trees will take whatever water is available and this will fluctuate considerably, changing daily), our exercise has produced the results shown on the following pages.

First, the change-by-month of ground levels measured using precise levels has been logged, but only for months where the ground has subsided – i.e., net water extraction. No account has been taken of values recording the ground rising even though the tree will have taken water through that month.



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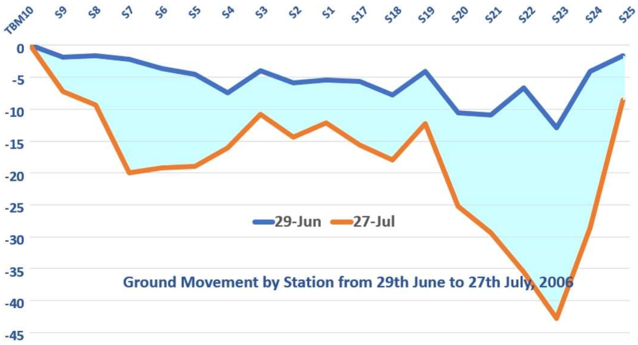
If that 'difference by month' registers a negative value, then water has been abstracted resulting in subsidence and the average across all 25 stations is calculated.

Readings are taken every 2mtrs from the 2 levelling arrays. See illustrative sketch below.



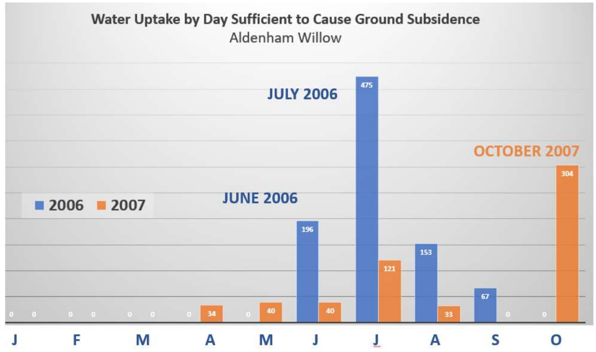
The blue shaded zone represents the area referred to as 'cumulative movement by month'.

In some months, the average might produce a value that is indicative of rehydration - the ground is higher than it was in the preceding month - in which case the values are ignored.

This is one of the many flaws in trying to estimate water uptake. For example, if rainfall exceeds water uptake by the willow, the ground may swell. This doesn't mean the tree isn't drinking water.

Similarly, some water will be lost by evaporation from the ground within the root zone. Not via the tree.

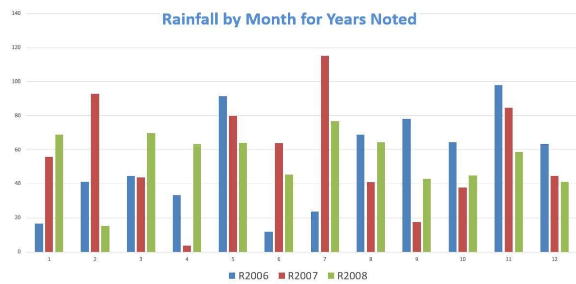
With these caveats in mind, the calculations revealed some interesting data which is shown below.



In 2006, water uptake peaked in July. The volumes exceeded those of 2007 by a significant amount as can be seen in the above graph.

In contrast, water uptake in 2007 gradually increased from April through to October. Perhaps the 'short, sharp shock' in July, 2006 was the trigger to delivering the high claim numbers in that year.

Looking now at the weather record and comparing it with data from precise levelling, the estimate of water uptake delivered by the levels was low in July 2007. Is this matched by a wetter month? Met Office weather records are reproduced below for the Heathrow station, confirming this to be the case.



To summarise, the study has little or no value in terms of delivering an accurate assessment of water uptake by the willow but that isn't the objective.

The study seeks to provide some idea of water uptake sufficient to produce subsidence within the root zone of the tree.

The output may have little value to plant physiologists, but it does provide background information to engineers investigating domestic subsidence claims.

Water Uptake by Day Sufficient to Cause Subsidence

	2006	2007
January	0	0
February	0	0
March	0	0
April	0	34
May	0	40
June	196	40
July	475	121
August	153	33
September	67	0
October	0	304
November	0	0
December	0	0

Estimate of water uptake by day (in gallons) sufficient to cause negative ground movement by the Aldenham willow for the months noted, where level data is available. The first readings were taken in May, 2006.

For example, in terms of the Intervention Technique, we need to understand the volume of water required to convert an event year into a normal year. Comparing profiles between 2006 and 2007 helps understand the drivers behind high claim numbers.

The water uptake in July 2006 was significantly more than in any other month. The data here suggest that soil drying may trigger an emergency response by the tree, resulting in this increased uptake.

This 'short, sharp, shock' delivered by the combination of low rainfall and high water uptake in July 2006, may well be the explanation for the late surge.

Had 400 gallons of water been added to the soil in June 2006, would ground movement have been reduced? Most probably.

More importantly, looking at the work done by plant biologists on Partial Root Drying, if water was made available to one part of the root zone would this influence the production of what is known as 'effective ABA' - the plant stress hormone?

This exercise has no predictive value but provides useful background information to understanding the underlying mechanism.

Do trees respond to drought by increasing their water demand?

The uptake is no doubt a complex mechanism and we know that hormones play a central role in regulating stomatal response to stress.

For our part, the interest lies in determining water uptake (volume and timing) sufficient to cause root induced clay shrinkage resulting in damage to a low-rise building.

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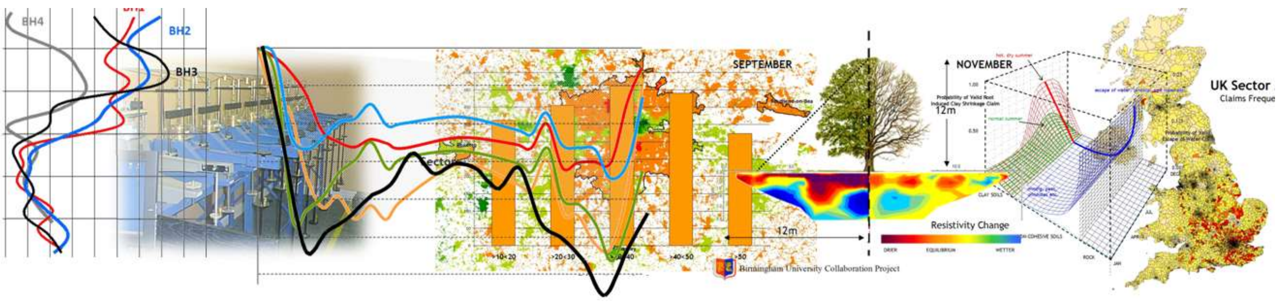

Water Uptake Caveat

The exercise to determine moisture uptake using precise levelling data records movement from a specific tree on a unique site in a particular location with a variable geology and unique weather conditions. Determining the total moisture uptake of vegetation is acknowledged to be a complex area and beyond the scope of this study.

Whilst precise levels might suggest the tree has taken ‘x’ gallons of water, this simplistic approach does not take account of rainfall in that period, or access to ‘free’ (i.e. unbound) water in sand lenses and fissures etc. The tree transpires far more water than the table in the study suggest.

Abscisic Acid – Stress Hormone

On the previous page we refer to Abscisic Acid (ABA). This has been covered in earlier editions of the newsletter, but by way of a reminder, ABA is a plant hormone that regulates the drought response of vegetation. It has a role in subsidence claims caused by root induced clay shrinkage.

Current research is primarily directed to resolving problems associated with crops growing in dry, arid climates, with low water availability. Plant physiologists have been trying to understand how to produce healthy plants that use less water and yet deliver abundant crops.

To summarise, ABA is known as a ‘root to shoot signalling hormone’ that has a major role in determining the response of vegetation under drought stress.

It is produced all of the time but lost through the root system under normal (non-stress) conditions. The pH of the cell is an important factor, and the site of action. Raising the pH (making the water more alkaline) enhances its effectiveness. Achieving this in the cell apoplast targets the stoma, causing them to close with a consequent reduction in water lost via transpiration.

All of this would be to no avail if specific receptors weren’t activated and much of the recent work has been directed to identification of the mechanism. In future editions we review current research into ABA.

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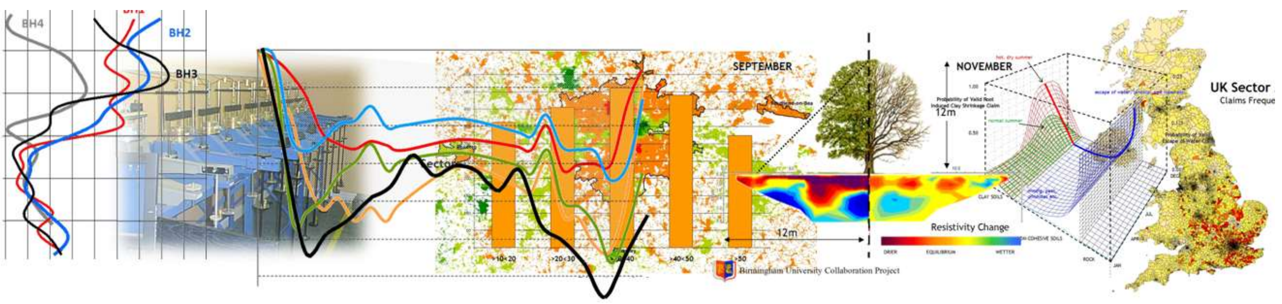

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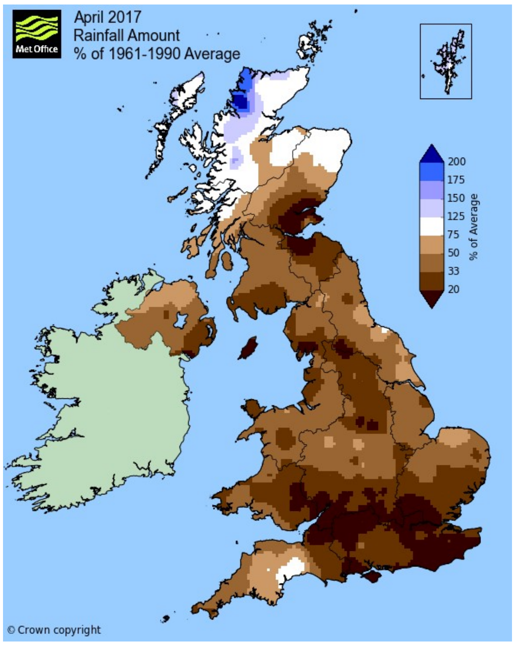
Met Office Weather Forecasts

Richard Rollit has provided the following extract from the Met Office web site for an insight into what the coming months might hold:

SUMMARY – TEMPERATURE: For May-June-July, above-average temperatures are more probable than below-average. Overall, the probability that the UK-average temperature for May-June-July will fall into the coldest of our five categories is 10% and the probability that it will fall into the warmest of our five categories is 35% (the 1981-2010 probability for each of these categories is 20%).

SUMMARY – PRECIPITATION: For May-June-July, above-average precipitation is considered slightly more probable than below-average, on balance. Overall, the probability that the UK-average precipitation for May-June-July will fall into the driest of our five categories is 20% and the probability that it will fall into the wettest of our five categories is around 25% (the 1981-2010 probability for each of these categories is 20%).

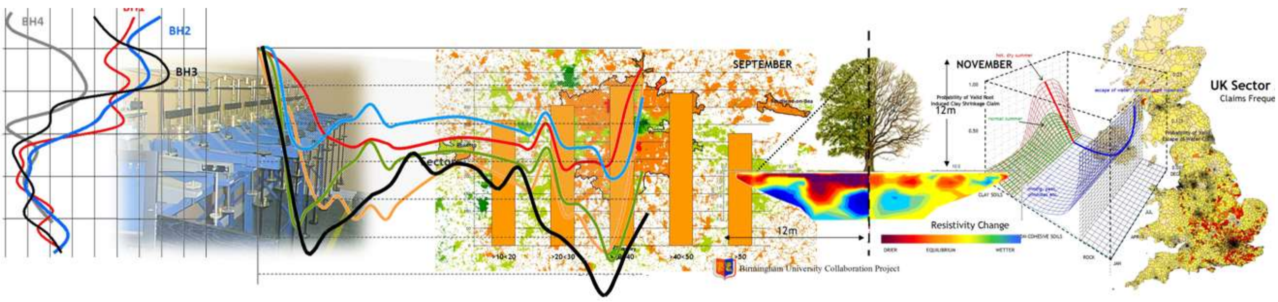


Met Office anomaly map for April, 2017, showing less rainfall across the UK relative to the 1961 – 1990 average.

Singing Trees

Dr. Jon Heuch spotted the following item about singing trees, broadcast on Canadian CBC Radio. It looks (or sounds) as though Simon Cowell may be missing a trick by not producing a "Britain's Got Talent" for trees. Jon has sent the following link for anyone wanting to check out hopeful contenders.

http://www.cbc.ca/radio/asithappens/as-it-happens-monday-edition-1.4072865/meet-the-biologist-who-says-trees-have-their-own-songs-1.4072909?platform=hootsuite



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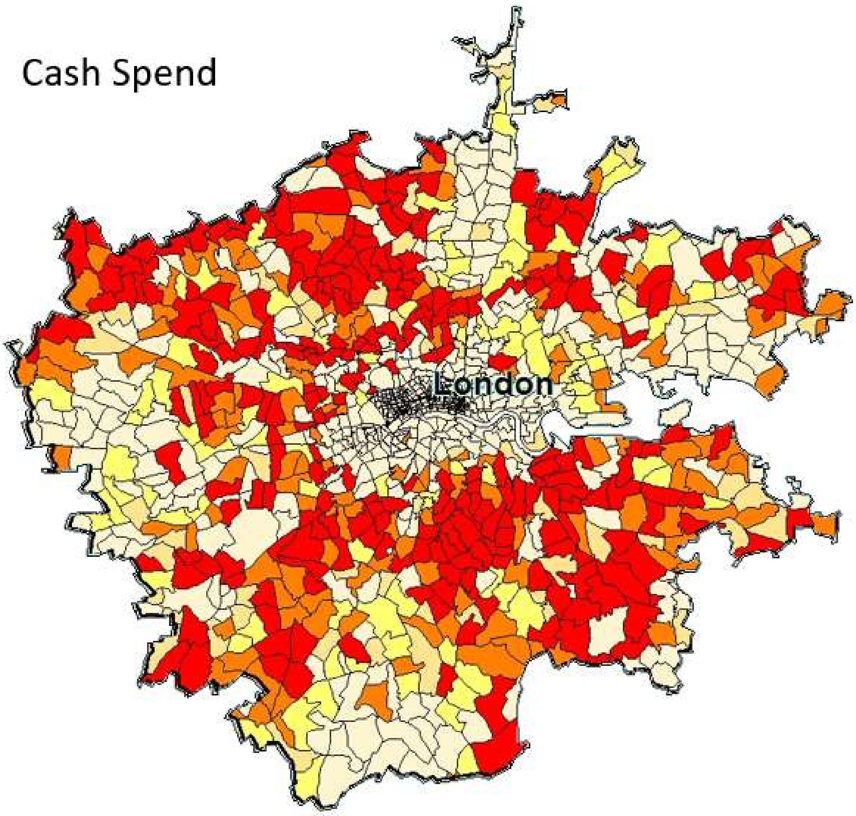
Mapping the Subsidence Risk

A series of maps covering the London area, revealing the links between peril, geology, housing, tree density and spend will appear over the next few months. The adoption of Geographic Information Systems (GIS) has helped insurers develop their understanding of the links between the various disparate elements.

Before this, underwriters would base premiums on claims experience but without necessarily understanding the cause of these variations across the UK.

GIS systems revealed the link between geology and risk, and as these updated images reveal, the distributions of claims, trees, soils, weather patterns, house types and ownership.

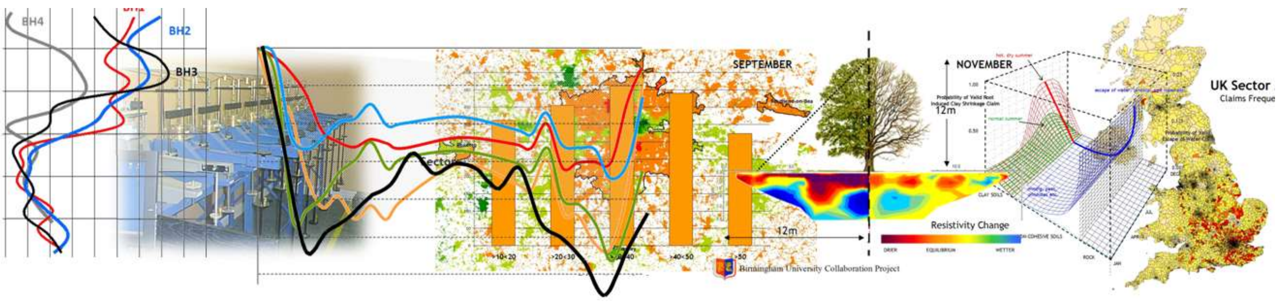


Average Spend by Postcode Sector

The relative standing (in terms of exposure) between the two perils – clay shrinkage and escape of water.

Clay shrinkage claims across the UK cost, on average, 20% more to settle than their counterparts.

This percentage increases with the PI of the clay. The 'high value' sectors, left, coincide with the clay related claims.



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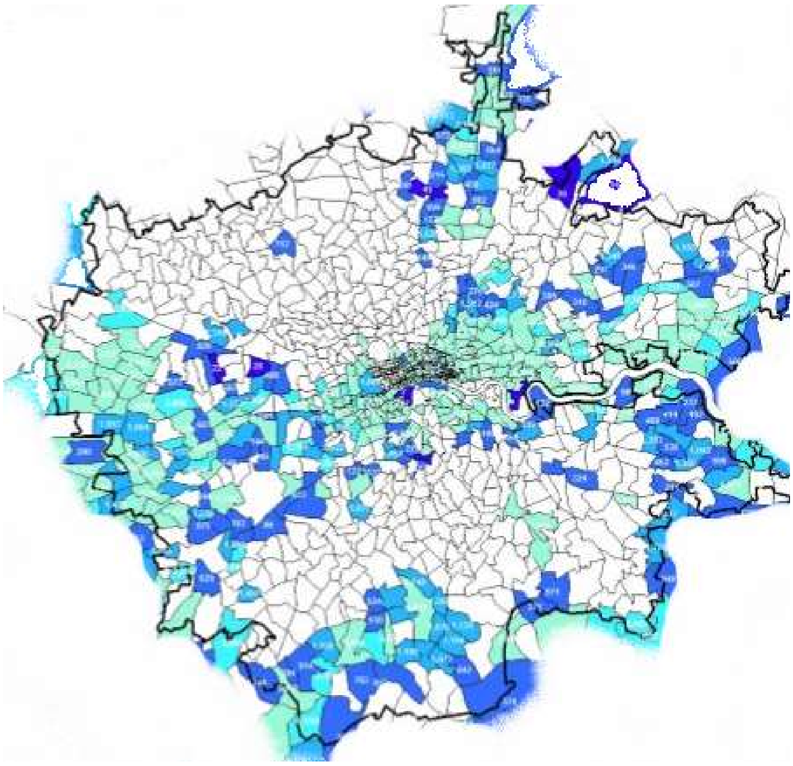

Escape of Water Claims by Postcode Sector

Subsidence caused primarily by leaking drains. The darker the shading, the higher the risk.

This is a proxy for understanding the geology. The escape of water peril is related to erosion or softening of non-cohesive soils.

The map reveals that the risk follows the areas of alluvium, and to the south, chalk.

Clay Shrinkage Claims by Postcode Sector

Right, a similar map plotting the risk of clay shrinkage claims across the study area.

In this example, the red and orange sectors reveal predominantly root induced clay shrinkage claims associated with the outcropping London clay series.